Glossary of Space Science Terminology

A

Accretion - Accumulation of dust and gas into larger bodies such as stars, planets and moons

Accretion disk - A relatively flat sheet of gas and dust surrounding a newborn star, a black hole, or any massive object growing in size by attracting material

Actinide - any of a series of chemically similar, mostly synthetic, radioactive elements with atomic numbers ranging above 89

Active galactic nuclei (AGN) - It is believed that these are normal galaxies with a massive black hole accreting gas at its center, thus producing enormous amounts of energy at all wavelengths of the electromagnetic spectrum

Alluvium - clay, silt, sand, gravel or similar detrital material deposited by running water

Angular size - width or diameter of an object measured as an angle from the observer's eyes, a way of stating the diameter/distance ratio for an object

Angstrom - A unit of length equal to 0.00000001 centimeters. Scientists sometimes write this as 1 x 10-8 cm (see scientific notation)

Apoapsis - The point in an orbit when the two objects are farthest apart. Special names are given to this orbital point for commonly used systems. For example, the point of greatest separation of two stars, as in a binary star orbit, is called apastron; the point in its orbit where a planet is farthest from the Sun is called aphelion; the point in its orbit where an Earth satellite is farthest from the Earth is called apogee

Apparent brightness - brightness of an object as seen by an observer dependent upon the object's wattage, if it is self-emitting, or upon the amount of light scattered or reflected

Apparent magnitude - a measure of the apparent brightness of an astronomical object, as observed from Earth. The scale of magnitudes is logarithmic

Asteroid - Chunks of rock that travel through space. The biggest asteroids are hundreds of miles wide, but most are as small as pebbles. Most asteroids lie in a ring, or belt, around the sun between the planets Jupiter and Mars

Astronaut - a person who travels in a spacecraft, esp. a crew member

Astronomical unit - (AU.) a unit of distance equal to the average distance between the earth and the sun, about 93 million miles; 149,597,870 km

Astronomy - The scientific study of matter in outer space, especially the positions, dimensions, distribution, motion, composition, energy, and evolution of celestial bodies and phenomena

Astrophysics - The part of astronomy that deals principally with the physics of stars, stellar systems, and interstellar material

Atmosphere - the gaseous mass or envelope surrounding a celestial body in space; The gas that surrounds a planet or star. The Earth'satmosphere is made up of mostly nitrogen, while the Sun's atmosphere consists of mostly hydrogen

Atom - a unit of matter, the smallest unit of an element, consisting of a dense, positively charged nucleus surrounded by a system of negatively charged electrons

Atomic – (1) of or relating to an atom, (2) of or employing nuclear energy, 3) very small

B

Binary stars - Binary stars are two stars that orbit around a common center of mass. An X-ray binary is a special case where one of the stars is a collapsed object such as a white dwarf, neutron star, or black hole. Matter is stripped from the normal star and falls onto the collapsed star, producing X-rays

Black hole - An object whose gravity is so strong that not even light can escape from it.

Black-hole dynamic laws - laws of black-hole dynamics: (1) First law of black hole dynamics: For interactions between black holes and normal matter, the conservation laws of mass-energy, electric charge, linear momentum, and angular momentum, hold. This is analogous to the first law of thermodynamics. (2) Second law of black hole dynamics: With black-hole interactions, or interactions between black holes and normal matter, the sum of the surface areas of all black holes involved can never decrease. This is analogous to the second law of thermodynamics, with the surface areas of the black holes being a measure of the entropy of the system

Blackbody radiation - The radiation or the radiance at particular frequencies all across the spectrum produced by a blackbody ,that is, a perfect radiator (and absorber) of heat. Physicists had difficulty explaining it until Planck introduced his quantum of action

Blackbody temperature - The temperature of an object if it is re-radiating all the thermal energy that has been added to it; if an object is not a blackbody radiator, it will not re-radiate all the excess heat and the leftover will go toward increasing its temperature

Blueshift - An apparent shift toward shorter wavelengths of spectral lines in the radiation emitted by an object caused by the emitting object moving toward the observer. See also Doppler effect

Boltzmann constant; k - A constant which describes the relationship between temperature and kinetic energy for molecules in an ideal gas. It is equal to 1.380622 x 10-23 J/K (see scientific notation)

Brahe, Tycho - 1546 - 1601 - (a.k.a Tyge Ottesen) Danish astronomer whose accurate astronomical observations formed the basis for Johannes Kepler's laws of planetary motion

Bremsstrahlung - "braking radiation", the main way very fast charged particles lose energy when traveling through matter. Radiation is emitted when charged particles are accelerated. In this case, the acceleration is caused by the electromagnetic fields of the atomic nuclei of the medium

C

Calibration - A process for translating the signals produced by a measuring instrument (such as a telescope) into something that is scientifically useful. This procedure removes most of the errors caused by environmental and instrumental instabilities

Chandrasekhar limit - (S. Chandrasekhar; 1910 - 1995) - A limit which mandates that no white dwarf (a collapsed, degenerate star) can be more massive than about 1.4 solar masses. Any degenerate object more massive must inevitably collapse into a neutron star

Cluster of galaxies - A system of galaxies containing from a few to a few thousand member galaxies which are all gravitationally bound to each other

Collecting area - The amount of area a telescope has that is capable of collecting electromagnetic radiation. Collecting area is important for a telescope's sensitivity: the more radiation it can collect (that is, the larger its collecting area), the more sensitive it is to dim objects

Comet - Comets are made of dust and ice and look like dirty snowballs. There are millions of them traveling through space

Compton effect - (A.H. Compton; 1923) - An effect that demonstrates that photons (the quantum of electromagnetic radiation) have momentum. A photon fired at a stationary particle, such as an electron, will impart momentum to the electron and, since its energy has been decreased, will experience a corresponding decrease in frequency

Concave - hollowed or rounded inward like the inside of a bowl

Constellation - A group of stars that makes a pattern. There are 88 constellations in our sky. Constellations seem to twinkle in the sky. This happens because moving air blurs starlight as it travels to Earth

Copernicus, Nicolaus - 1473 - 1543 - Polish astronomer who advanced the heliocentric theory that the Earth and other planets revolve around the Sun. This was highly controversial at the time as the Ptolemaic view of the universe, which was the prevailing theory for over 1000 years, was deeply ingrained in the prevailing philosophy and religion. (It should be noted, however, that the heliocentric idea was first put forth by Aristarcus of Samos in the 3rd century B.C., a fact known to Copernicus but long ignored.

Corona - (plural: coronae) The uppermost level of the solar atmosphere, characterized by low densities and high temperatures (> 1,000,000 degrees K)

Cosmic background radiation - primal glow - The background of radiation mostly in the frequency range 3 x 108 to 3 x 1011 Hz (see scientific notation) discovered in space in 1965. It is believed to be the cosmologically redshifted radiation released by the Big Bang itself.

Cosmic rays Atomic nuclei (mostly protons) and electrons that are observed to strike the Earth's atmosphere with exceedingly high energies

Cosmological constant - G + Lambda g = 8 pi T

Cosmological distance - A distance far beyond the boundaries of our Galaxy. When viewing objects at cosmological distances, the curved nature of spacetime could become apparent. Possible cosmological effects include time dilation and redshift

Cosmological redshift - An effect where light emitted from a distant source appears redshifted because of the expansion of spacetime itself

Cosmology - The astrophysical study of the history, structure, and constituent dynamics of the universe

D

De Broglie wavelength - (L. de Broglie; 1924) - According to quantum mechanics all particles also have wave characteristics, where the wavelength of a particle is inversely proportional to its momentum and the constant of proportionality is the Planck constant

Declination - A coordinate which, along with Right Ascension, may be used to locate any position in the sky. Declination is analogous to latitude for locating positions on the Earth

Deconvolution - An image processing technique that removes features in an image that are caused by the telescope itself rather than from actual light coming from the sky

Density - The amount of mass of any substance which can be contained in one cubic centimeter. Measured in grams per cubic centimeter (or kilograms per liter); the density of water is 1.0; iron is 7.9; lead is 11.3

Disk - (of planet or other object) - The apparent circular shape that the Sun, a planet, or a moon displays when seen in the sky or through a telescope

Doppler effect - (C.J. Doppler) - The apparent change in wavelength of sound or light caused by the motion of the source, observer or both. Waves emitted by a moving object as received by an observer will be blueshifted (compressed) if approaching, redshifted (elongated) if receding. It occurs both in sound and light. How much the frequency changes depends on how fast the object is moving toward or away from the receiver. Compare cosmological redshift

E

Eccentric - on-circular; elliptical (applied to an orbit)

Eccentricity - A value that defines the shape of an ellipse or planetary orbit. The eccentricity of an ellipse (planetary orbit) is the ratio of the distance between the foci and the major axis. Equivalently the eccentricity is (ra-rp)/(ra+rp) where ra is the apoapsis distance and rp is the periapsis distance

Eclipse - The cutting off, or blocking, of light from one celestial body by another

Ecliptic - The plane of Earth's orbit about the Sun

Eddington limit - (Sir A. Eddington) - The theoretical limit at which the photon pressure would exceed the gravitational attraction of a light-emitting body. That is, a body emitting radiation at greater than the Eddington limit would break up from its own photon pressure

Einstein, Albert - 1879 - 1955 - German-American physicist; developed the Special and General Theories of Relativity which along with Quantum Mechanics is the foundation of modern physics

Ejecta - Material that is ejected. Used mostly to describe the content of a massive star that is propelled outward in a supernova explosion

Electromagnetic spectrum - The full range of frequencies, from radio waves to gamma-rays, that characterizes light

Electromagnetic waves - (radiation) - Another term for light. Light waves are fluctuations of electric and magnetic fields in space

Electron - A particle commonly found in the outer layers of atoms with a negative charge. The electron has only 0.0005 the mass of the proton

Electron volt - The change of potential energy experienced by an electron moving from a place where the potential has a value of V to a place where it has a value of (V+1 volt). This is a convenient energy unit when dealing with the motions of electrons and ions in electric fields; the unit is also the one used to describe the energy of X-rays and gamma-rays. A keV (or kiloelectron volt) is equal to 1000 electron volts. An MeV is equal to one million electron volts. A GeV is equal to one billion (109) electron volts. A TeV is equal to a million million (1012) electron volts

Elements - The fundamental kinds of atoms that make up the building blocks of matter, which are each shown on the periodic table of the elements. The most abundant elements in the universe are hydrogen and helium. These two elements make up about 80 and 20 % of all the matter in the universe respectively. Despite comprising only a very small fraction in the universe, the remaining heavy elements can greatly influence astronomical phenomena. About 2 % of the Milky Way's disk is comprised of heavy elements

Ellipse - Oval. That the orbits of the planets are ellipses, not circles, was first discovered by Johannes Kepler based on the careful observations by Tycho Brahe

Erg/sec - A form of the metric unit for power. It is equal to 10-10 kilowatts (see scientific notation)

Erosion - the process of wearing away by the action of water, wind or ice

Event horizon - The radius that a spherical mass must be compressed to in order to transform it into a black hole, or the radius at which time and space switch responsibilities. Once inside the event horizon, it is fundamentally impossible to escape to the outside. Furthermore, nothing can prevent a particle from hitting the singularity in a very short amount of proper time once it has entered the horizon. In this sense, the event horizon is a "point of no return"

Evolved star - A star near the end of its lifetime when most of its fuel has been used up. This period of the star's life is characterized by loss of mass from its surface in the form of a stellar wind

Expanding Universe - Astronomers have discovered that distant galaxies are moving away from the Milky Way and also from each other. The whole universe is expanding or becoming bigger

Extragalactic - Outside of, or beyond, our own galaxy.

F

False Color - Color added to a photograph of an object, such as a galaxy, to make it look clearer

Fermi acceleration - In order to explain the origins of cosmic rays, Enrico Fermi (1949) introduced a mechanism of particle acceleration, whereby charged particles bounce off moving interstellar magnetic fields and either gain or lose energy, depending on whether the "magnetic mirror" is approaching or receding. In a typical environment, he argued, the probability of a head-on collision is greater than a head-tail collision, so particles would be accelerated on average. This random process is now called 2nd order Fermi acceleration, because the mean energy gain per "bounce" is dependent on the "mirror" velocity squared. Bell (1978) and Blandford and Ostriker (1978) independently showed that Fermi acceleration by supernova remnant (SNR) shocks is particularly efficient, because the motions are not random. A charged particle ahead of the shock front can pass through the shock and then be scattered by magnetic inhomogeneities behind the shock. The particle gains energy from this "bounce" and flies back across the shock, where it can be scattered by magnetic inhomogeneities ahead of the shock. This enables the particle to bounce back and forth again and again, gaining energy each time. This process is now called 1st order Fermi acceleration, because the mean energy gain is dependent on the shock velocity only to the first power

Fluvial - of or relating to living in streams, produced by stream action

Flux - flowing of fluid from the body, or an excessive abnormal discharge from the bowels

Frequency - A property of a wave that describes how many wave patterns or cycles pass by in a period of time. Frequency is often measured in Hertz (Hz), where a wave with a frequency of 1 Hz will pass by at 1 cycle per second

G

Galactic halo - A spherical region surrounding the center of a galaxy. This region may extend beyond the luminous boundaries of the galaxy and contain a significant fraction of the galaxy's mass. Compared to cosmological distances, objects in the halo of our galaxy would be very nearby

Galaxy - A component of our universe made up of gas and a large number (usually more than a million) of stars held together by gravity

Galilei, Galileo - (1564 - 1642) - An Italian scientist, Galileo was renowned for his epoch making contribution to physics, astronomy, and scientific philosophy. He is regarded as the chief founder of modern science. He developed the telescope, with which he found craters on the Moon and discovered the largest moons of Jupiter. Galileo was condemned by the Catholic Church for his view of the cosmos based on the theory of Copernicus

Gamma-ray - The highest energy, shortest wavelength electromagnetic radiations. Usually, they are thought of as any photons having energies greater than about 100 keV

Gravitational collapse - When a massive body collapses under its own weight. (For example, interstellar clouds collapse to become stars until the onset of nuclear fusion stops the collapse.)

Gamma-Ray Burst (GRB) - Plural is GRBs. A burst of gamma-rays from space lasting from a fraction of a second to many minutes. There is no clear scientific consensus as to their cause or even their distance

General relativity - The geometric theory of gravitation developed by Albert Einstein, incorporating and extending the theory of special relativity to accelerated frames of reference and introducing the principle that gravitational and inertial forces are equivalent

Giant Molecular Cloud (GMC) - Massive clouds of gas in interstellar space composed primarily of hydrogen molecules (two hydrogen atoms bound together), though also containing other molecules observable by radio telescopes. These clouds can contain enough mass to make several million stars like our Sun and are often the sites of star formation

Gravity - A mutual physical force between two bodies. Most agree that it is an attracting force while some think that it may be a force that pushes the bodies together

Guest star - The ancient Chinese term for a star that newly appears in the night sky, and then later disappears. Later, the Europeans called this a nova

H

Hawking radiation - (S.W. Hawking; 1973) - The theory that black holes emit radiation like any other hot body. Virtual particle-antiparticle pairs are constantly being created in supposedly empty space. Occasionally, a pair will be created just outside the event horizon of a black hole. There are three possibilities: (1) both particles are captured by the hole; (2) both particles escape the hole; (3) one particle escapes while the other is captured. The first two cases are straightforward; the virtual particle-antiparticle pair recombine and return their energy back to the void via the uncertainty principle. It is the third case that interests us. In this case, one of the particles has escaped (and is speeding away to infinity), while the other has been captured by the hole. The escapee becomes real and can now be detected by distant observers. But the captured particle is still virtual; because of this, it has to restore conservation of energy by assigning itself a negative mass-energy. Since the hole has absorbed it, the hole loses mass and thus appears to shrink. From a distance, it appears as if the hole has emitted a particle and reduced in mass. The rate of power emission is proportional to the inverse square of the hole's mass; thus, the smaller a hole gets, the faster and faster it emits Hawking radiation. This leads to a runaway process; what happens when the hole gets very small is unclear; quantum theory seems to indicate that some kind of "remnant" might be left behind after the hole has emitted away all its mass-energy

Hawking temperature - The temperature of a black hole caused by the emission of Hawking radiation

Herschel, Sir William - (1738 - 1822) - Sir William Herschel was a renowned astronomer who first detected the infrared region of the electromagnetic spectrum in 1800

Hertz, Heinrich - (1857 - 1894) - A German physics professor who did the first experiments with generating and receiving electromagnetic waves, in particular radio waves. In his honor, the units associated with measuring the cycles per second of the waves (or the number of times the tip-tops of the waves pass a fixed point in space in 1 second of time) is called the hertz.
Hertz Hz (after H. Hertz, 1857 - 1894) - The derived SI unit of frequency, defined as a frequency of 1 cycle per second

Hubble, Edwin P. - 1889 - 1953 - American astronomer whose observations proved that galaxies are "island universes", not nebulae inside our own galaxy. His greatest discovery was the linear relationship between a galaxy's distance and the speed with which it is moving. The Hubble Space Telescope is named in his honor

Hubble constant - Ho (E.P. Hubble; 1925) - The constant which determines the relationship between the distance to a galaxy and its velocity of recession due to the expansion of the Universe. Since the Universe is self-gravitating, it is not truly constant. In cosmology, it is defined as H = (da/dt)/a, where a is the 4-radius of the Universe. When evaluated for the present, it is written H0 = Hnow. The Hubble constant is not known to great accuracy (only within about a factor of 2), but is believed to lie somewhere between 50 and 100 km/s/Mpc

Hubble's law - (E.P. Hubble; 1925) - A relationship discovered between distance and radial velocity. The further away a galaxy is from us, the faster it is receding from us. The constant of proportionality is the Hubble constant, H_0. The cause is interpreted as the expansion of spacetime itself

Huygens, Christiaan - (1629 - 1695) - A Dutch physicist who was the leading proponent of the wave theory of light. He also made important contributions to mechanics, stating that in a collision between bodies, neither loses nor gains ``motion'' (his term for momentum). In astronomy, he discovered Titan (Saturn's largest moon) and was the first to correctly identify the observed elongation of Saturn as the presence of Saturn's rings

I

Implosion - A violent inward collapse. An inward explosion

Infrared - Electromagnetic radiation at wavelengths longer than the red end of visible light and shorter than microwaves (roughly between 1 and 100 microns). Almost none of the infrared portion of the electromagnetic spectrum can reach the surface of the Earth, although some portions can be observed by high-altitude aircraft (such as the Kuiper Observatory) or telescopes on high mountaintops (such as the peak of Mauna Loa in Hawaii)

Inclination - The inclination of a planet's orbit is the angle between the plane of its orbit and the ecliptic; the inclination of a moon's orbit is the angle between the plane of its orbit and the plane of its primary's equator

Image - in astronomy, a picture of the sky

Interstellar medium - The gas and dust between stars, which fills the plane of the Galaxy much like air fills the world we live in. For centuries, scientists believed that the space between the stars was empty. It wasn't until the eighteenth century, when William Herschel observed nebulous patches of sky through his telescope, that serious consideration was given to the notion that interstellar space was something to study. It was only in the last century that observations of interstellar material suggested that it was not even uniformly distributed through space, but that it had a unique structure

Ions - An atom with one or more electrons stripped off, giving it a net positive charge

Ionic (or ionized) gas - Gas whose atoms have lost or gained electrons, causing them to be electrically charged. In astronomy, this term is most often used to describe the gas around hot stars where the high temperature causes atoms to lose electrons

J

Jets - Beams of particles, usually coming from an active galactic nucleus or a pulsar. Unlike a jet airplane, when the stream of gas is in one direction, astrophysical jets come in pairs with each jet aiming in opposite directions

K

Kelvin - (after Lord Kelvin, 1824 - 1907) - A temperature scale often used in sciences such as astronomy. The fundamental SI unit of thermodynamic temperature defined as 1/273.16 of the thermodynamic temperature of the triple point of water. The Kelvin temperature scale is just like the Celsius scale except that the freezing point of water, zero degrees Celsius, is equal to 273 degrees Kelvin. (K = C + 273o) (F = 9/5C + 32o)

Kepler, Johannes - 1571 - 1630 - German astronomer and mathematician. Considered a founder of modern astronomy, he formulated the famous three laws of planetary motion. They comprise a quantitative formulation of Copernicus's theory that the planets revolve around the Sun

Kepler's laws - (J. Kepler) (1) Kepler's first law - A planet orbits the Sun in an ellipse with the Sun at one focus, (2) Kepler's second law - A ray directed from the Sun to a planet sweeps out equal areas in equal times, (3) Kepler's third law - The square of the period of a planet's orbit is proportional to the cube of that planet's semimajor axis; the constant of proportionality is the same for all planets

Kilogram (kg) - One kilogram is equivalent to 1,000 grams or 2.2 pounds; the mass of a liter of water. The fundamental SI unit of mass, it is the only SI unit still maintained by a physical artifact: a platinum-iridium bar kept in the International Bureau of Weights and Measures at Sevres, France

Kinematics - Refers to the calculation or description of the underlying mechanics of motion of an astronomical object. For example, in radioastronomy, spectral line graphs are used to determine the kinematics or relative motions of material at the center of a galaxy or surrounding a star as it is born

Kirchhoff's law of radiation - (G.R. Kirchhoff) The emissivity of a body is equal to its absorbance at the same temperature

Kirchhoff's laws - (G.R. Kirchhoff) (1) Kirchhoff's first law. An incandescent solid or gas under high pressure will produce a continuous spectrum (2) Kirchhoff's second law - A low-density gas will radiate an emission-line spectrum with an underlying emission continuum. (3) Kirchhoff's third law - Continuous radiation viewed through a low-density gas will produce an absorption-line spectrum

L

Lagrange, Joseph - (1736 - 1813) - A French mathematician of the eighteenth century. His work Mecanique Analytique (Analytical Mechanics; 1788) was a mathematical masterpiece. It contained clear, symmetrical notation and covered almost every area of pure mathematics. Lagrange developed the calculus of variations, established the theory of differential equations, and provided many new solutions and theorems in number theory. His classic Theorie des fonctions analytiques laid some of the foundations of group theory. Lagrange also invented the method of solving differential equations known as variation of parameters

Lagrange points - Points in the vicinity of two massive bodies (such as the Earth and the Moon) where each others' respective gravities balance. There are five, labeled L1 through L5. L1, L2, and L3 lie along the centerline between the centers of mass between the two masses; L1 is on the inward side of the secondary, L2 is on the outward side of the secondary; and L3 is on the outward side of the primary. L4 and L5, the so-called Trojan points, lie along the orbit of the secondary around the primary, sixty degrees ahead and behind of the secondary. L1 through L3 are points of unstable equilibrium; any disturbance will move a test particle there out of the Lagrange point. L4 and L5 are points of stable equilibrium, provided that the mass of the secondary is less than about 1/25.96 the mass of the primary. These points are stable because centrifugal pseudo-forces work against gravity to cancel it out

Light - Electromagnetic radiation that is visible to the human eye

Light curve - A graph that displays the time variation in light or magnitude of a variable or eclipsing star

Light year - A unit of length used in astronomy which equals the distance light travels in a year. At the rate of 300,000 kilometers per second (671 million miles per hour), 1 light-year is equivalent to 9.46053 x 1012 km, 5,880,000,000,000 miles or 63,240 a.u

Limb - The outer edge of the apparent disk of a celestial body

M

Magnetic field - A condition found in the region around a magnet or an electric current, characterized by the existence of a detectable magnetic force at every point in the region

Magnetic pole - Either of two limited regions in a magnet at which the magnet's field is most intense

Magnetosphere - The region of space in which the magnetic field of an object (e.g., a star or planet) dominates the radiation pressure of the stellar wind to which it is exposed

Magnetotail - The portion of a planetary magnetosphere which is pushed in the direction of the solar wind

Magnitude - The degree of brightness of a celestial body designated on a numerical scale, on which the brightest star has magnitude -1.4 and the faintest visible star has magnitude 6, with the scale rule such that a decrease of one unit represents an increase in apparent brightness by a factor of 2.512; also called apparent magnitude

Mass - A measure of the total amount of material in a body, defined either by the inertial properties of the body or by its gravitational influence on other bodies

Matter - A word used for any kind of stuff which contains mass

Mega-ton - A unit of energy used to describe nuclear warheads. The same amount energy as 1 million tons of TNT. 1 mega-ton = 4 x 1016 ergs = 4 x 109 joules

Meteor or shooting stars - Small rocks and dust left behind from comets that enter the Earth’s atmosphere

Meteorite - Chunks of rock that don't burn up when they enter the atmosphere and fall to earth

Meteoroid - any solid object moving in interplanetary space that is smaller than a planet or asteroid but larger than a molecule. If a meteoroid enters Earth's atmosphere, we call it a meteorite after it falls to the surface. The light that it produces as it passes through the atmosphere is commonly called a shooting star.

Meter - (m) The fundamental SI unit of length, defined as the length of the path traveled by light in vacuum during a period of 1/299 792458 s. A unit of length equal to about 39 inches. A kilometer is equal to 1000 meters

Microwave - Electromagnetic radiation which has a long wavelength (between 1 mm and 30 cm). Microwaves can be used to study the Universe, communicate with satellites in Earth orbit, and cook popcorn

Milky Way - A spiral shaped galaxy in which the Earth is located. The sun and the earth lie in one of the spiral arms near the edge of the galaxy

Moon - A natural object in space that travels around a planet. A moon is smaller than its planet

Morphology - the external structure of rocks in relation to the development of erosion forms or topographic features

N

Nebula - A diffuse mass of interstellar dust and gas inside a galaxy

Neutrino - A fundamental particle produced in massive numbers by the nuclear reactions in stars; they are very hard to detect because the vast majority of them pass completely through the Earth without interacting

Neutron - A particle commonly found in the nucleus of atoms with approximately the mass of a proton, but zero charge

Neutron star - The imploded core of a massive star produced by a supernova explosion. (typical mass of 1.4 times the mass of the Sun, radius of about 5 miles, density of a neutron.) According to astronomer and author Frank Shu, "A sugar cube of neutron-star stuff on Earth would weigh as much as all of humanity!" Neutron stars can be observed as pulsars

Newton, Isaac - 1642 - 1727 - English cleric and scientist; discovered the classical laws of motion and gravity; the bit with the apple is probably apocryphal

Newton's law of universal gravitation - (Sir I. Newton) - Two bodies attract each other with equal and opposite forces; the magnitude of this force is proportional to the product of the two masses and is also proportional to the inverse square of the distance between the centers of mass of the two bodies

Newton's laws of motion - (Sir I. Newton) (1) Newton's first law of motion: A body continues in its state of constant velocity (which may be zero) unless it is acted upon by an external force. (2) Newton's second law of motion - For an unbalanced force acting on a body, the acceleration produced is proportional to the force impressed; the constant of proportionality is the inertial mass of the body. (3) Newton's third law of motion - In a system where no external forces are present, every action force is always opposed by an equal and opposite reaction

Noise - The random fluctuations that are always associated with a measurement that is repeated many times over. Noise appears in astronomical images as fluctuations in the image background. These fluctuations do not represent any real sources of light in the sky, but rather are caused by the imperfections of the telescope. If the noise is too high, it may obscure the dimmest objects within the field of view

Nova - (plural: novae) - A star that experiences a sudden outburst of radiant energy, temporarily increasing its luminosity by hundreds to thousands of times before fading back to its original luminosity

Nuclear fusion - nuclear process whereby several small nuclei are combined to make a larger one whose mass is slightly smaller than the sum of the small ones. The difference in mass is converted to energy by Einstein's famous equivalence "Energy = Mass times the Speed of Light squared". This is the source of the Sun's energy

O

Occultation - The blockage of light by the intervention of another object; a planet can occult (block) the light from a distant star

Opacity - A property of matter that prevents light from passing through it; non-transparent. The opacity or opaqueness of something depends on the frequency of the light. For instance, the atmosphere of Venus is transparent to ultraviolet light, but is opaque to visual light

Orbit - The path of an object that is moving around a second object or point

P

Pair production - The physical process whereby a gamma-ray photon, usually through an interaction with the electromagnetic field of a nucleus, produces an electron and an anti-electron (positron). The original photon no longer exists, its energy having gone to the two resulting particles. The inverse process, pair annihilation, creates two gamma-ray photons from the mutual destruction of an electron/positron pair

Parallax - The angle between the two straight lines that join a celestial body to two different points of observation; e.g., two different points on the Earth as it moves through space

Parsec - A large distance often used in astronomy, it is equal to 3.26 light years, or 3.1 x 1018 cm (see scientific notation). A kiloparsec (kpc) is equal to 1000 parsecs. A megaparsec (Mpc) is equal to a million (106) parsecs. An object is at a distance of 1 parsec from us if its parallax is 1 second of arc

Periapsis - The point in the orbit closest to the planet

Periastron - The point of closest approach of two stars, as in a binary star orbit

Perigee - The point in the orbit closest to the Earth

Perihelion - The point in its orbit where a planet is closest to the Sun. when referring to objects orbiting the Earth the term perigee is used; the term periapsis is used for orbits around other bodies. (opposite of aphelion)

Photoelectric effect - An effect explained by A. Einstein which demonstrates that light seems to be made up of particles, or photons. Light can excite electrons (called photoelectrons in this context) to be ejected from a metal. Light with a frequency below a certain threshold, at any intensity, will not cause any photoelectrons to be emitted from the metal. Above that frequency, photoelectrons are emitted in proportion to the intensity of incident light. The reason is that a photon has energy in proportion to its wavelength, and the constant of proportionality is the Planck constant. Below a certain frequency -- and thus below a certain energy -- the incident photons do not have enough energy to knock the photoelectrons out of the metal. Above that threshold energy, called the work function, photons will knock the photoelectrons out of the metal, in proportion to the number of photons (the intensity of the light). At higher frequencies and energies, the photoelectrons ejected obtain a kinetic energy corresponding to the difference between the photon's energy and the work function

Pi - The constant equal to the ratio of the circumference of a circle to its diameter, which is approximately 3.141593

Planck constant - h - The fundamental constant equal to the ratio of the energy of a quantum of energy to its frequency. It is the quantum of action. It has the value 6.626196 x 10-34 J s

Planck equation - The quantum mechanical equation relating the energy of a photon E to its frequency nu: E = h x nu

Planet - A large round object in space, such as Earth, that travels around the sun or another star

Planetary nebula - A shell of gas ejected from, and expanding about, a certain kind of extremely hot star

Plasma - A low-density gas in which the individual atoms are ionized (and therefore charged), even though the total number of positive and negative charges is equal, maintaining an overall electrical neutrality

Polarization - A special property of light; light has three properties, brightness, color and polarization. Polarization is a condition in which the planes of vibration of the various rays in a light beam are at least partially aligned

Pole Star - The name of the star that lies almost directly above the North Pole, which is the most northern place on planet Earth

Positron - The antiparticle to the electron. The positron has most of the same characteristics as an electron except it is positively charged

Postulate - to assume

Probe - to investigate thoroughly, to make an exploratory investigation

Projectile - a body projected by external force and continuing in force by its own inertia

Prominence - a huge tongue or loop of gas that rises high above the sun's surface

Proton - A particle commonly found in the nucleus of atoms with a positive charge

Protostar - Very dense regions (or cores) of molecular clouds where stars are in the process of forming

Ptolemy - (ca. 100-ca. 170) - a.k.a.Claudius Ptolemaeus. Ptolemy believed the planets and Sun to orbit the Earth in the order Mercury, Venus, Sun, Mars, Jupiter, Saturn. This system became known as the Ptolemaic system and predicted the positions of the planets accurately enough for naked-eye observations (although it made some ridiculous predictions, such as that the distance to the moon should vary by a factor of two over its orbit). He authored a book called Mathematical Syntaxis (widely known as the Almagest). The Almagest included a star catalog containing 48 constellations, using the names we still use today

Pulsar - A rotating neutron star which generates regular pulses of radiation. Pulsars were discovered by observations at radio wavelengths but have since been observed at optical, X-ray, and gamma-ray energies

Q

Quasar - A specific type of quasi-stellar source

Quasi-stellar source (QSS) - Sometimes also called quasi-stellar object (QSO); A stellar-appearing object of very large redshift that is a strong source of radio waves; presumed to be extragalactic and highly luminous

R

Radial velocity - The speed at which an object is moving away or toward an observer. By observing spectral lines, astronomers can determine how fast objects are moving away from or toward us; however, these spectral lines cannot be used to measure how fast the objects are moving across the sky

Radian; rad - The supplementary SI unit of angular measure, defined as the central angle of a circle whose subtended arc is equal to the radius of the circle

Radiation - Energy radiated in the form of waves or particles; photons

Radiation belt - Regions of charged particles in a magnetosphere

Radio Electromagnetic Radiation - Has the lowest frequency, the longest wavelength, and is produced by charged particles moving back and forth; the atmosphere of the Earth is transparent to radio waves with wavelengths from a few millimeters to about twenty meters

Rayleigh-Taylor instabilities - Rayleigh-Taylor instabilities occur when a heavy (more dense) fluid is pushed against a light fluid -- like trying to balance water on top of air by filling a glass 1/2 full and carefully turning it over. Rayleigh-Taylor instabilities are important in many astronomical objects, because the two fluids trade places by sticking "fingers" into each other. These "fingers" can drag the magnetic field lines along with them, thus both enhancing and aligning the magnetic field

Red giant - A star that has low surface temperature and a diameter that is large relative to the Sun

Redshift - An apparent shift toward longer wavelengths of spectral lines in the radiation emitted by an object caused by the emitting object moving away from the observer. See also Doppler effect

Reflection law - For a wavefront intersecting a reflecting surface, the angle of incidence is equal to the angle of reflection, in the same plane defined by the ray of incidence and the normal

Relativity principle - The principle, employed by Einstein's relativity theories, that the laws of physics are the same, at least locally, in all coordinate frames. This principle, along with the principle of the constancy of the speed of light, constitutes the founding principles of special relativity

Relativity, theory of - More accurately describes the motions of bodies in strong gravitational fields or at near the speed of light than Newtonian mechanics. All experiments done to date agree with relativity's predictions to a high degree of accuracy. (Curiously, Einstein received the Nobel prize in 1921 not for Relativity but rather for his 1905 work on the photoelectric effect.)

Resolution (spatial) - In astronomy, the ability of a telescope to differentiate between two objects in the sky which are separated by a small angular distance. The closer two objects can be while still allowing the telescope to see them as two distinct objects, the higher the resolution of the telescope

Resolution (spectral or frequency) - Similar to spatial resolution except that it applies to frequency, spectral resolution is the ability of the telescope to differentiate two light signals which differ in frequency by a small amount. The closer the two signals are in frequency while still allowing the telescope to separate them as two distinct components, the higher the spectral resolution of the telescope

Resonance - A relationship in which the orbital period of one body is related to that of another by a simple integer fraction, such as 1/2, 2/3, 3/5

Retrograde - The rotation or orbital motion of an object in a clockwise direction when viewed from the north pole of the ecliptic; moving in the opposite sense from the great majority of solar system bodies

Right Ascension - A coordinate which, along with declination, may be used to locate any position in the sky. Right ascension is analogous to longitude for locating positions on the Earth

Ritter, Johann Wilhelm - (1776 - 1810) - Ritter is credited with discovering and investigating the ultraviolet region of the electromagnetic spectrum

Roche limit - The smallest distance from a planet or other body at which purely gravitational forces can hold together a satellite or secondary body of the same mean density as the primary; at less than this distance the tidal forces of the primary would break up the secondary

Roche lobe - The volume around a star in a binary system in which, if you were to release a particle, it would fall back onto the surface of that star. A particle released above the Roche lobe of either star will, in general, occupy the `circumbinary' region that surrounds both stars. The point at which the Roche lobes of the two stars touch is called the inner Lagrangian or L1 point. If a star in a close binary system evolves to the point at which it `fills' its Roche lobe, theoretical

calculations predict that material from this star will overflow both onto the companion star (via the L1 point) and into the circumbinary environment

Roentgen, Wilhelm Conrad (1845 - 1923) - A German scientist who fortuitously discovered X-rays in 1895

S

Satellite - A body that revolves around a larger body

Schwarzschild radius - The radius r of the event horizon for a Schwarzschild black hole

Scientific notation - A compact format for writing very large or very small numbers, most often used in scientific fields. The notation separates a number into two parts: a decimal fraction, usually between 1 and 10, and a power of ten. Thus 1.23 x 104 means 1.23 times 10 to the fourth power or 12,300; 5.67 x 10-8 means 5.67 divided by 10 to the eighth power or 0.0000000567

Second; s - The fundamental SI unit of time, defined as the period of time equal to the duration of 9,192,631,770 periods of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium-133 atom. A nanosecond is equal to one-billionth (10-9) of a second

Semimajor axis - The semimajor axis of an ellipse (e.g. a planetary orbit) is 1/2 the length of the major axis which is a segment of a line passing thru the foci of the ellipse with endpoints on the ellipse itself. The semimajor axis of a planetary orbit is also the average distance from the planet to its primary. The periapsis and apoapsis distances can be calculated from the semimajor axis and the eccentricity by rp = a(1-e) and ra = a(1+e)

Sensitivity - A measure of how bright objects need to be in order for that telescope to detect these objects. A highly sensitive telescope can detect dim objects, while a telescope with low sensitivity can detect only bright ones

Seyfert galaxy - A spiral galaxy whose nucleus shows bright emission lines; one of a class of galaxies first described by C. Seyfert

Shock wave - A strong compression wave where there is a sudden change in gas velocity, density, pressure and temperature

Singularity - The center of a black hole, where the curvature of spacetime is maximal. At the singularity, the gravitational tides diverge; no solid object can even theoretically survive hitting the singularity. Although singularities generally predict inconsistencies in theory, singularities within black holes do not necessarily imply that general relativity is incomplete so long as singularities are always surrounded by event horizons. A proper formulation of quantum gravity may well avoid the classical singularity at the centers of black holes

Solar flares - Violent eruptions of gas on the Sun's surface

Solar mass - A unit of mass equivalent to the mass of the Sun. 1 solar mass = 1 Msun = 2 x 1033 grams

Special relativity - The physical theory of space and time developed by Albert Einstein, based on the postulates that all the laws of physics are equally valid in all frames of reference moving

at a uniform velocity and that the speed of light from a uniformly moving source is always the same, regardless of how fast or slow the source or its observer is moving. The theory has as consequences the relativistic mass increase of rapidly moving objects, gravitational sources bending light, time dilatation, and the principle of mass-energy equivalence. See also general relativity

Spectral line - Light given off at a specific frequency by an atom or molecule. Every different type of atom or molecule gives off light at its own unique set of frequencies; thus, astronomers can look for gas containing a particular atom or molecule by tuning the telescope to one of its characteristic frequencies. For example, carbon monoxide (CO) has a spectral line at 115 Gigahertz (or a wavelength of 2.7 mm)

Spectrometer - The instrument connected to a telescope that separates the light signals into different frequencies, producing a spectrum. A Diversive Spectrometer is like a prism. It scatters the X-rays of different energies to different places. We measure the energy by noting where the X-rays go. A Non-Dispersive Spectrometer measures the energy directly

Spectroscopy - The study of spectral lines from different atoms and molecules. Spectroscopy is an important part of studying the chemistry that goes on in stars and in interstellar clouds

Spectrum - (plural: spectra) - A plot of the intensity of light at different frequencies. Or the distribution of wavelengths and frequencies

Speed of light - (in vacuo) - The speed at which electromagnetic radiation propagates in a vacuum; it is defined as 299,792,458 m/s (186,000 miles/second). Einstein's Theory of Relativity implies that nothing can go faster than the speed of light

Star - A large ball of gas that creates and emits its own radiation

Star cluster - A bunch of stars (ranging in number from a few to hundreds of thousands) which are bound to each other by their mutual gravitational attraction

Stellar classification - Stars are given a designation consisting of a letter and a number according to the nature of their spectral lines which corresponds roughly to surface temperature. The classes are: O, B, A, F, G, K, and M; O stars are the hottest; M the coolest. The numbers are simply subdivisions of the major classes. The classes are oddly sequenced because they were assigned long ago before we understood their relationship to temperature. O and B stars are rare but very bright; M stars are numerous but dim. The Sun is designated G2

Stellar wind - The ejection of gas off the surface of a star. Many different types of stars, including our Sun, have stellar winds; however, a star's wind is strongest near the end of its life when it has consumed most of its fuel

Steradian; sr - The supplementary SI unit of solid angle defined as the solid central angle of a sphere that encloses a surface on the sphere equal to the square of the sphere's radius

Stratigraphic - geology that deals with the origin, composition, and distribution

Substrate - the base in which an organism lives

Supernova - (plural: supernovae) - The death explosion of a massive star, resulting in a sharp increase in brightness followed by a gradual fading. At peak light output, supernova explosions

can outshine a galaxy. The outer layers of the exploding star are blasted out in a radioactive cloud. This expanding cloud, visible long after the initial explosion fades from view, forms a supernova remnant (SNR)

Sunspots - Cooler (and thus darker) regions on the sun where the magnetic field loops up out of the solar surface

Synchronous rotation - aid of a satellite if the period of its rotation about its axis is the same as the period of its orbit around its primary. This implies that the satellite always keeps the same hemisphere facing its primary (e.g. the Moon). It also implies that one hemisphere (the leading hemisphere) always faces in the direction of the satellite's motion while the other (trailing) one always faces backward

Synchrotron radiation - Electromagnetic radiation given off when very high energy electrons encounter magnetic fields

Systeme Internationale d'Units (SI) - The coherent and rationalized system of units, derived from the MKS system (which itself is derived from the metric system), in common use in physics today. The fundamental SI unit of length is the meter, of time is the second, and of mass is the kilogram

T

Terrestrial - of or relating to the Earth or its inhabitants

Thomson, William - 1824 - 1907 - Also known as Lord Kelvin, the British physicist who developed the Kelvin scale of temperature and who supervised the laying of a trans-Atlantic cable

Time dilation - Stretching of time produced by relativity. Time dilation is a predicted effect of the cosmological paradigm

Topography - the art or practice of graphic delineation in detail usually on maps or charts of natural or man-made features of a place or region especially in a way to show their relative positions and elevations

U

Ultraviolet - Electromagnetic radiation at wavelengths shorter than the violet end of visible light; the atmosphere of the Earth effectively blocks the transmission of most ultraviolet light

Universe - Everything in space is part of the universe. Scientists think it was formed 10 to 15 billions years ago with a big explosion. When the universe cooled down, huge swirls of dust and gas clung together to form galaxies

Universal constant of gravitation; G - The constant of proportionality in Newton's law of universal gravitation and which plays an analogous role in A. Einstein's general relativity. It is equal to 6.664 x 10-11 newtons per square meter per kilogram squared (see scientific notation)

V

The Venera satellite series - The Venera satellites were a series of probes (fly-bys and landers) sent by the Soviet Union to the planet Venus. Several Venera satellites carried high-energy astrophysics detectors

Visible - Electromagnetic radiation at wavelengths which the human eye can see. We perceive this radiation as colors ranging from red (longer wavelengths; ~ 700 nanometers) to violet (shorter wavelengths; ~400 nanometers.)

W

Wave-particle duality - The principle of quantum mechanics which implies that light (and, indeed, all other subatomic particles) sometimes act like a wave, and sometimes act like a particle, depending on the experiment you are performing. For instance, low frequency electromagnetic radiation tends to act more like a wave than a particle; high frequency electromagnetic radiation tends to act more like a particle than a wave

Wavelength - A property of a wave that gives the length between two peaks of the wave

White dwarf - A star that has exhausted most or all of its nuclear fuel and has collapsed to a very small size. Typically, a white dwarf has a radius equal to about 0.01 times that of the Sun, but it has a mass roughly equal to the Sun's. This gives a white dwarf a density about 1 million times that of water!

Wien's displacement law - For a blackbody, the product of the wavelength corresponding to the maximum radiancy and the thermodynamic temperature is a constant. As a result, as the temperature rises, the maximum of the radiant energy shifts toward the shorter wavelength (higher frequency and energy) end of the spectrum

X

X-ray - Electromagnetic radiation of very short wavelength and very high-energy; X-rays have shorter wavelengths than ultraviolet light but longer wavelengths than cosmic rays

Y

Z

Zenith – the point on the celestial sphere vertical above a given position or observer

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